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FRICTIONAL RESISTANCE OF DIFFERENT TYPES OF SELF-LIGATING BRACKETS WITH DIFFERENT WIRE COMBINATIONS

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ABSTRACT

The purpose of this study was to compare the effect of the mode of ligation on the frictional resistance of ceramic brackets and the effect of the bracket material on the frictional resistance whether it is static or kinetic. To achieve this one passive self-ligating ceramic bracket (Damon Clear 2), one active self-ligating ceramic bracket (Empower Clear) in addition to one passive self-ligating metal bracket (Damon Q) were used. These brackets were coupled with two sizes of stainless steel (SS) archwires (0.017 x 0.025-in and 0.019 x 0.025-in). A universal testing machine was used to pull the brackets along the straight distal end of the wire segments at a crosshead speed of 5 mm/min over a distance of 8 mm/min. The test was undergone under dry conditions. The results showed that the passive self-ligating brackets (PSLB) had significantly lower static friction (SF) and kinetic friction (KF) than the active self-ligating bracket (ASLB) with no significant differences between the ceramic and metal PSLB's. Also inceasing wire size increased the SF and KF for the PSLB's but did not affect the ASLB significantly.

INTRODUCTION

Self-ligation is the incorporation of a special mechanism in a preadjusted bracket allowing it to hold the wire in the bracket slot which was first introduced as the Russel attachment in 1935[1]. Then major changes were introduced to self-ligating brackets allowing them to be either active by pressing the wire against the slot base or passive by embracing the wire in the slot. This mechanism was meant to decrease the frictional resistance between the bracket and the wire by decreasing the normal forces. This was reported in literature when the difference between the frictional resistance of conventional and self-ligating brackets was examined[2, 3]. This can be beneficial especially with ceramic brackets due to their inherently increased frictional resistance over that of metal brackets caused by the nature of the material (Cacciafesta et al., 2003[4]; Doshi and Bhad-Patil, 2011[5]; Fidalgo et al., 2011[6]). Also comparisons were made to detect the differences between the frictional resistance of active and passive self-ligating brackets (Lee et al., 2015[7]; Leal et al., 2014[8]). Therefore, the aim of this study was to compare the two types of frictional

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resistance to sliding (static and kinetic) of those of the ceramic active and passive self-ligating brackets and a metal passive self-ligating bracket with two sizes of stainless steel rectangular wires.

MATERIALS AND METHODOLOGY

Three types of brackets were used in this study for comparison of their sliding resistance: a metal self-ligating bracket and two ceramic self-ligating brackets. The metal and one ceramic bracket were Damon Q and Damon Clear 2 respectively, both are passive self-ligating brackets (Ormco, Orange, CA, USA). The other ceramic bracket was the active self-ligating bracket Empower Clear (American Orthodontics, Sheboygan, Wisconsin, USA). These brackets were coupled with Each a 0.017 x 0.025-in SS and 0.019 x 0.025-in SS archwire to test their resistance to sliding. All the brackets were maxillary right canines with a 0.022 x 0.028-in slot.

The ceramic brackets were made of polycrystalline alumina. The PSLB's had a sliding door that does not grip the wire inside the slot but holds it passively and had a 7^{o} torque and a 5^{o} angulation. The ASLB's grip the wire inside the bracket slot by means of an interactive clip that actively engages archwire sizes of 0.017 x 0.025-in and larger in a 0.022 slot and they have a 0^{o} torque and an 8^{o} angulation. The brackets were bonded on a metal block with a curved surface using epoxy resin. A special trough like structure was custom made with its internal dimensions the same as those of the metal blocks. Five blocks were aligned in this structure and the brackets were aligned to make sure all the brackets are bonded on the same position on the blocks. Two edge wise brackets one on each side and a 0.021 x 0.025-in SS wire jig were used to overcome the prescription differences between the brackets.

A custom designed attachment composed of two parts, an upper part holding the block/bracket assembly and a lower part holding the wire segment. A universal testing machine (Instron Model 3345, Norwood, MA, USA) was used to slide the brackets along the distal end of the archwires which were cut into two halves at the mid line. The test was performed under dry conditions at a crosshead speed of 5 mm/min over a distance of 8 mm that resembles the mean mesiodistal premolar width.[6, 9] Each test was repeated 15 times for each bracket/archwire combination. Each bracket and wire segment were used only once for testing.

The data were collected and processed using the Bluehill software designed for use with the Instron machines. The SF was represented as the highest force recorded. The KF was represented as the mean of eight readings recorded for each test as the bracket slid along 8 mm of the wire segment (a reading every 1 mm) which sums as 120 readings for each bracket/wire combination with a total of 720 readings through the experiment and all the readings were recorded in Newton (N).

Statistical Analysis

Data was analyzed using Statistical Package for Social Science software computer program version 17 (SPSS, Inc., Chicago, IL, USA). Data were presented in mean and standard deviation. One way ANOVA followed by post-hoc tukey was used to compare between different groups. Two way ANOVA (analysis of variance) was used to detect effect of wire and brackets on static and kinetic friction followed by post-hoc sidak. P value less than 0.05 was considered statistically significant.

RESULTS

Effect of the types and materials of brackets on static and kinetic friction:

Table (1) and the histograms (**Figure 1,2**) showed the metal brackets had the least SF (0.133 and 0.424) and KF (0.049 and 0.07) for the 0.017 x 0.025 and 0.019 x 0.025-in wires respectively, however there was no significance between the metal and ceramic PSLB's with both wire sizes. The ASLB on the other hand showed the highest SF and KF.

Effect of the wire size on the static and kinetic friction:

Tables (2 & 3) show that the SF and KF were affected by the size of the wires as it increased from 0.017 x 0.025 to 0.019 x 0.025-in showing an increase in both the SF and KF. For all the bracket types the results were statistically significant except for the ASLB.

TABLE (1): Mean static frictions of the three bracket types with both wire sizes

Wires			Groups			P	P1	P2	P3
			Damon	Empower	Damon Q				
SF	17 x 25	Mean	.182	1.373	.133	<0.05*	<0.05*	0.9	<0.05*
		±SD	.111	.671	.086				
	19 x 25	Mean	.722	1.843	.424	<0.05*	<0.05*	0.29	<0.05*
		±SD	.418	.797	.235				
KF	17 x 25	Mean	.075	.926	.049	<0.05*	<0.05*	0.97	<0.05*
		±SD	.041	.567	.028				
	19 x 25	Mean	.396	1.314	.256	<0.05*	<0.05*	0.7	<0.05*
		±SD	.241	.767	.070				

SD: standard deviation ***P:Probability*** ****:significance <0.05***

Test used: One way ANOVA followed by post-hoc tukey

P1: significance between Damon & Empower groups

P2: significance between Damon & Damon-Q groups

P3: significance between Empower & Damon-Q groups

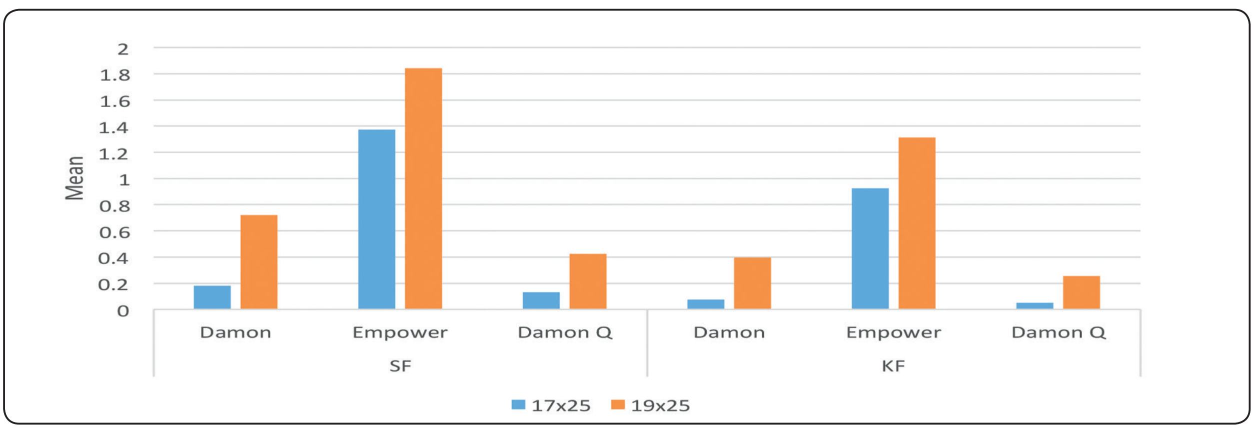

Fig. (1) Histogram showing comparison between the different brackets and their effect on static and kinetic frictions

TABLE (2) Mean static and kinetic frictions of the two wire sizes combined with the three bracket types

Friction	Bracket	Wire				P
		17x25.mil		19x25.mil		
		Mean	±SD	Mean	±SD	
SF	Damon	.182	.111	.722	.418	<0.05*
	Empower	1.373	.671	1.843	.797	0.09
	Damon Q	.133	.086	.424	.235	<0.05*
KF	Damon	.075	.041	.396	.241	<0.05*
	Empower	.926	.567	1.314	.767	0.12
	Damon Q	.049	.028	.256	.070	<0.05*

SD: standard deviation ***P:Probability*** ****:significance <0.05*** ***Test used: Student's t-test***

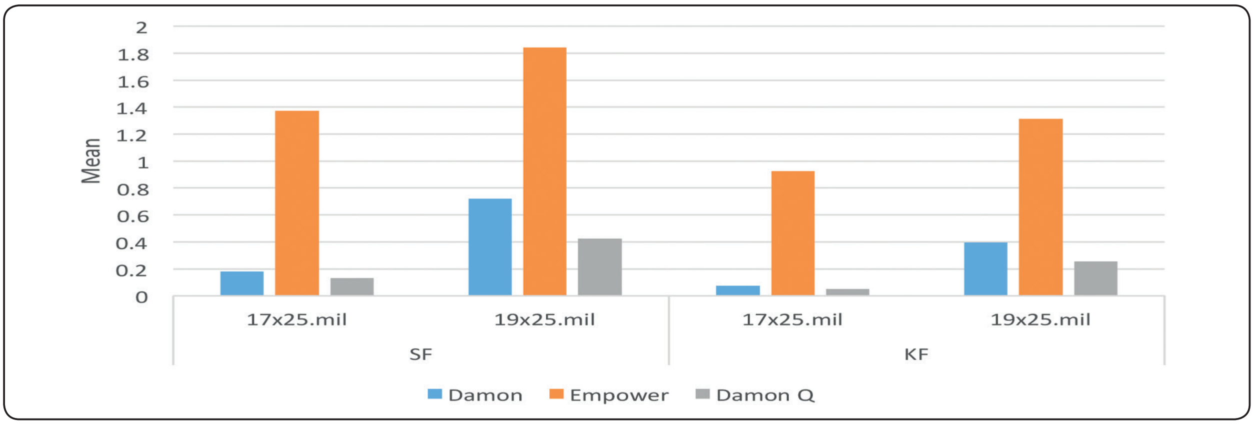

Fig. (2) histogram showing the effect of increasing the wire size on the static and kinetic frictions of the three bracket types

Two-way ANOVA:

Table (3) Effect of the bracket size and the size of wire on the static and kinetic frictions

Fricrtion		**Groups**			**P1**	**P2**	**P3**
		Damon	**Empower**	**Damon Q**			
Static friction	**Mean**	**.452**	**1.608**	**.279**	**<0.001****	**0.4**	**<0.001****
	±SD	**.407**	**.762**	**.229**			
Kinetic friction	**Mean**	**.235**	**1.120**	**.152**	**<0.001****	**0.8**	**<0.001****
	±SD	**.236**	**.691**	**.117**			

SD: standard deviation ***P:Probability*** ****:significance <0.05*** *****: high significance <0.001***

P1: significance between Damon & Empower groups

P2: significance between Damon & Damon-Q groups

P3: significance between Empower & Damon-Q groups

DISCUSSION

The results of this study showed a significant increase in the static and kinetic friction of the ASLB over the PSLB's that confirmed the results other studies[7, 10-12]. However the bracket material didn't affect the frictional properties of the SLB's as was also seen in previous studies[7, 13-16]. And it also showed that the resistance to sliding was affected by the size of the wire for the passive but not the active SLB's[17].

Passive vs active self-ligation

Some studies showed no significant differences between the passive and active self-ligating brackets under certain conditions. That was seen when a tipping force was applied to the system in one study[18]. In other studies where a moment was applied[14, 19], there was no differences between the active and passive brackets[14]. However, the difference between the two types of ligation disappeared in the other study[19] as the moment increased from 2000 to 4000 gm.mm and this can be attributed to the rigidity of the passive ligation that increases the friction under deflection. Also in another study[20], the shape of the wire showed its effect. There was no significant differences between Damon MX bracket and Time3 (ASLB) with rectangular wires. However, a significant difference was seen between another PSLB which showed less frictional forces than the other brackets (Damon MX and Time3). This they attributed to the shape of the sliding mechanism that is not the case in this study as the two PSLB's have nearly the same design.

The bracket material

Two studies[21, 22] showed less friction for the ceramic brackets than the metal ones where, in the first study[21] an active self-ligating ceramic bracket showed less static and kinetic frictions than its metal equivalent. This was attributed to the rhodium coating of its clip. However, in the other study[22] the decreased friction of the monocrystalline ceramic bracket than the metal brackets may be attributed to the artificial saliva used which was not used in the present study. Other studies[4-6, 23-26] showed an increase in the frictional forces of the ceramic brackets than those of the metal ones. However, in these studies the brackets used were conventional brackets but in the present study the type of ligation could have an effect on the results showing no significant differences between the ceramic and the metal PSLB's but increased friction for the ceramic ASLB.

The effect of the wire size

One study[9] showed no differences between the passive and active brackets at smaller wire sizes where there is a space of clearance between the wire and the bracket slot. As the wire size increased and the clearance disappeared, the active brackets showed higher frictional resistance, which can be attributed to the spring mechanism of the active brackets that pushes the wire in the bracket slot. Other studies[18, 27] also showed opposite results to those of our present study, where increasing the wire size increased the frictional resistance for the active but not for the passive. In the first study[18] this can be attributed to the difference in the experimental setup and the difference in the ligation mechanism between both types of brackets. However in the second study[27] they found that increasing the wire depth but not its height increases the frictional resistance of the active brackets and this shows the effect of the amount of clearance and the spring mechanism in increasing the friction.

REFERENCES

1. Harradine N. The History and Development of Self-Ligating Brackets. Semin Orthod. 2008;14(1):5-18.
2. Reicheneder CA, Gedrange T, Berrisch S, Proff P, Baumert U, Faltermeier A, Muessig D. Conventionally ligated versus self-ligating metal brackets--a comparative study. Eur J Orthod. 2008;30(6):654-60.
3. Castro RM, Neto PS, Horta MC, Pithon MM, Oliveira DD. Comparison of static friction with self-ligating, modified slot design and conventional brackets. J Appl Oral Sci. 2013;21(4):314-9.

4. Cacciafesta V, Sfondrini MF, Scribante A, Klersy C, Auricchio F. Evaluation of friction of conventional and metal-insert ceramic brackets in various bracket-archwire combinations. Am J Orthod Dentofacial Orthop. 2003;124(4):403-9.

5. Doshi UH, Bhad-Patil WA. Static frictional force and surface roughness of various bracket and wire combinations. Am J Orthod Dentofacial Orthop. 2011;139(1):74-9.

6. Fidalgo TK, Pithon MM, Maciel JV, Bolognese AM. Friction between different wire bracket combinations in artificial saliva--an in vitro evaluation. J Appl Oral Sci. 2011;19(1):57-62.

7. Lee SM, Hwang CJ. A comparative study of frictional force in self-ligating brackets according to the bracket-archwire angulation, bracket material, and wire type. Korean J Orthod. 2015;45(1):13-9.

8. Leal RC, Amaral FL, Franca FM, Basting RT, Turssi CP. Role of lubricants on friction between self-ligating brackets and archwires. Angle Orthod. 2014;84(6):1049-53.

9. Thorstenson GA, Kusy RP. Effect of archwire size and material on the resistance to sliding of self-ligating brackets with second-order angulation in the dry state. Am J Orthod and Dentofacial Orthop. 2002;122(3):295-305.

10. Smith DV, Rossouw P, Watson P. Quantified Simulation of Canine Retraction: Evaluation of Frictional Resistance. Semin Orthod. 2003;9(4):262-80.

11. Hain M, Dhopatkar A, Rock P. A comparison of different ligation methods on friction. Am J Orthod Dentofacial Orthop. 2006;130(5):666-70.

12. Budd S, Daskalogiannakis J, Tompson BD. A study of the frictional characteristics of four commercially available self-ligating bracket systems. Eur J Orthod. 2008;30(6):645-53.

13. Voudouris JC, Schismenos C, Lackovic K, Kuftinec MM. Self-ligation esthetic brackets with low frictional resistance. Angle Orthod. 2010;80(1):188-94.

14. Pliska BT, Fuchs RW, Beyer JP, Larson BE. Effect of applied moment on resistance to sliding among esthetic self-ligating brackets. Angle Orthod. 2014;84(1):134-9.

15. Baccetti T, Franchi L, Camporesi M. Forces in the presence of ceramic versus stainless steel brackets with unconventional vs conventional ligatures. Angle Orthod. 2008;78(1):120-4.

16. Karim Soltani M, Golfeshan F, Alizadeh Y, Mehrzad J. Resistance to Sliding in Clear and Metallic Damon 3 and Conventional Edgewise Brackets: an In vitro Study. J Dent. 2015;16(1 Suppl):15-20.

17. Yeh CL, Kusnoto B, Viana G, Evans CA, Drummond JL. In-vitro evaluation of frictional resistance between brackets with passive-ligation designs. Am J Orthod Dentofacial Orthop. 2007;131(6):704 e11-22.

18. Brauchli LM, Senn C, Wichelhaus A. Active and passive self-ligation-a myth? Angle Orthod. 2011;81(2):312-8.

19. Pliska BT, Beyer JP, Larson BE. A comparison of resistance to sliding of self-ligating brackets under an increasing applied moment. Angle Orthod. 2011;81(5):794-9.

20. Tecco S, Di Iorio D, Nucera R, Di Bisceglie B, Cordasco G, Festa F. Evaluation of the friction of self-ligating and conventional bracket systems. Eur J Dent. 2011;5(3):310-7.

21. Stefanos S, Secchi AG, Coby G, Tanna N, Mante FK. Friction between various self-ligating brackets and archwire couples during sliding mechanics. Am J Orthod Dentofacial Orthop. 2010;138(4):463-7.

22. Arash V, Rabiee M, Rakhshan V, Khorasani S, Sobouti F. In vitro evaluation of frictional forces of two ceramic orthodontic brackets versus a stainless steel bracket in combination with two types of archwires. J Orthod Sci. 2015;4(2):42-6.

23. Nishio C, da Motta AF, Elias CN, Mucha JN. In vitro evaluation of frictional forces between archwires and ceramic brackets. Am J Orthod Dentofacial Orthop. 2004;125(1):56-64.

24. Sukh R, Singh GK, Tandon P, Singh GP, Singh A. A comparative study of frictional resistance during simulated canine retraction on typodont model. J Orthod Sci. 2013;2(2):61-6.

25. Kumar BS, Miryala S, Kumar KK, Shameem K, Regalla RR. Comparative Evaluation of Friction Resistance of Titanium, Stainless Steel, Ceramic and Ceramic with Metal Insert Brackets with Varying Dimensions of Stainless Steel Wire: An In vitro Multi-center Study. J Int Oral Health. 2014;6(5):66-71.

26. Kannan MS, Murali RV, Kishorekumar S, Gnanashanmugam K, Jayanth V. Comparison of frictional resistance of esthetic and semi-esthetic self-ligating brackets. J Pharm Bioallied Sci. 2015;7(Suppl 1):S116-20.

27. Oliver CL, Daskalogiannakis J, Tompson BD. Archwire depth is a significant parameter in the frictional resistance of active and interactive, but not passive, self-ligating brackets. Angle Orthod. 2011;81(6):1036-44.